
USACE/NAVFAC/AFCEA UFGS-L-16303N (February 2003)

Preparing Activity: Superseding
LANTNAVFACENGCOM UFGS-L-16303N (September 2002)
Use in lieu of UFGS-16302N

UNIFIED FACILITIES GUIDE SPECIFICATIONS

Use for LANTNAVFACENGCOM projects only

Revised throughout - Format changes and reference dates not indicated by
CHG tags. Other revisions are indicated by CHG tags.

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SECTION 16303N

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02/03

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SECTION 16303N

UNDERGROUND ELECTRICAL WORK
02/03

NOTE: This guide specification covers underground
electrical work, basic to underground electrical and
telecommunication distribution systems. This guide
specification, UFGS-L-16303N, is issued by the
Atlantic Division, Naval Facilities Engineering
Command for regional use in lieu of UFGS 16302N,
"Underground Transmission and Distribution". It
replaces UFGS-L-16303N dated September 2002 in its
entirety. This version is available on the LANTDIV
Home Page located at
http://www.efdlant.navfac.navy.mil/lantops_04/home.htm
and shall be used on current LANTDIV projects.

NOTE: The following information should be shown on
the drawings.

- a. Where specification identifies type, size,
color, finish, or other definitive information to be
"as indicated," the engineer shall include the
information on the drawings.
- b. Location of manholes, handholes, ducts, and
cables.
- c. Types of wire and cable; number and sizes of
conductors.
- d. Do not include sketches in project
specifications. Use underground sketches as details
on drawings whenever possible. If special features
are required for a project, do not revise sketches,
but indicate these changes as notes below the
detail. Sketch numbers and dates should remain on
the drawing details.

e. Circuit identification.

f. Special conditions.

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
(AASHTO)

AASHTO HB (2002) Highway Bridges

AASHTO M198 (1998) Joints for Circular Concrete Sewer and Culvert Pipe Using Flexible Watertight Gaskets (ASTM C990-96)

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 315 (1999) Details and Detailing of Concrete Reinforcement

ACI 318M/318RM (2002) Building Code Requirements for Structural Concrete (ACI 318M-02) and Commentary (ACI 318RM-02)

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS1 (1990) Impregnated Paper Insulated, Lead Covered Cable, Solid Type

NOTE: AEIC CS5 (1994) "Cross-linked Polyethylene Insulated Shielded Power Cable Rated 5 Through 46 kV" has been replaced by AEIC CS8

AEIC CS6 (1996) Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 through 69 kV

AEIC CS8 (2000) Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A48/A48M (2000) Gray Iron Castings

ASTM B1 (2001) Hard-Drawn Copper Wire

ASTM B8 (1999) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM C32 (1993; R 1999, E1-1999) Sewer and Manhole

	Brick (Made from Clay or Shale) AASHTO No.: M91-78
ASTM C139	(2001) Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C260	(2001) Air-Entraining Admixtures for Concrete
ASTM C309	(1998; Rev A) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C478	(2002) Precast Reinforced Concrete Manhole Sections
ASTM C478M	(1997) Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C857	(1995; R 2001) Minimum Structural Design Loading for Underground Precast Concrete Utility Structures

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2002; Errata 2002) Structural Welding Code - Steel
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**NOTE: The following reference is included for
design information only.**

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

**FAA AC-150/5320-6 (1995; Rev. D) Airport Pavement
Design and Evaluation**

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-60005	(1998) Frames, Covers, Gratings, Steps, Sump and Catch Basin, Manhole
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INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE)

IEEE C2	(2002) National Electrical Safety Code (ANSI/IEEE)
IEEE 48	(1996) Alternating-Current Cable Terminations 2.5 kV Through 765 kV
IEEE 404	(2000) Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V

MASTER PAINTERS INSTITUTE (MPI)

MPI 79	(2002) Alkyd Anti-Corrosive Metal Primer
MPI 94	(2002) Exterior Alkyd, Semi-Gloss

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA C119.1 (2002) Electric Connectors - Sealed
Insulated Underground Connector Systems
Rated 600 Volts

NEMA RN 1 (1998) Polyvinyl-Chloride (PVC) Externally
Coated Galvanized Rigid Steel Conduit and
Intermediate Metal Conduit

NEMA TC 2 (1998) Electrical Polyvinyl Chloride (PVC)
Tubing and Conduit

NEMA TC 3 (1999) PVC Fittings for Use with Rigid PVC
Conduit and Tubing

NEMA TC 6 & 8 (1999) PVC Plastic Utilities Duct for
Underground Installations

NEMA TC 9 (1999) Fittings for PVC Plastic Utilities
Duct for Underground Installation

NOTE: NEMA WC 7 (1988; R 1991, Rev. 1991, 1992,
and 1996)

"Cross-Linked-Thermosetting-Polyethylene-
Insulated Wire and Cable for the Transmission and
Distribution of Electrical Energy ICEA No.
S-66-524" has been withdrawn.

NOTE: NEMA WC 8 (1988; Rev. 1992 and 1996)
"Ethylene-Propylene-Rubber-Insulated Wire and
Cable for the Transmission and Distribution of
Electrical Energy ICEA S-68-516" has been
withdrawn.

NEMA WC 74 (2000) 5 - 46 kV Shielded Power Cable for
Use in the Transmission & Distribution of
Electric Energy ICEA S-93-639; Supersedes
WC 3, WC 5, WC 7, and WC 8

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS (1999) Electrical Power Distribution
Equipment and Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2002) National Electrical Code

STEEL STRUCTURES PAINTING COUNCIL (SSPC)

SSPC SP 1 (1982; Ed 2000) Solvent Cleaning

SSPC SP 2 (1982; Ed 2000) Hand Tool Cleaning

SSPC SP 3	(1982; Ed 2000) Power Tool Cleaning
UNDERWRITERS LABORATORIES INC. (UL)	
UL 6	(2000; Bul. 2001, 2002) Rigid Metal Conduit - Steel
UL 83	(1998; R 2001, Bul. 2001, 2002) Thermoplastic-Insulated Wires and Cables
UL 467	(1993; R 2001) Grounding and Bonding Equipment
UL 486A	(1997; R 2001, Bul. 2002, 2003) Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL 486B	(1997; R 2001, Bul. 2002, 2003) Wire Connectors for Use with Aluminum Conductors
UL 510	(1994; R 1998) Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
UL 514A	(1996; R 2001, Bul. 2001, 2002) Metallic Outlet Boxes
UL 514B	(1997; R 2002, Bul. 2001, 2002) Fittings for Cable and Conduit
UL 651	(1995; R 2002) Schedule 40 and 80 Rigid PVC Conduit
UL 651A	(2000; R 2002) Type EB and A Rigid PVC Conduit and HDPE Conduit
UL 854	(1999; R 2002, Bul. 2001, 2002) Service-Entrance Cables
UL 1072	(2001; Bul. 2000, 2002, 2003) Medium-Voltage Power Cables
UL 1242	(2000; R 2001, Bul. 2002) Intermediate Metal Conduit

NOTE: Specification Section 16081N, "Apparatus Inspection and Testing" applies only when medium voltage cable, medium voltage cable splices or medium voltage terminations are included in the project.

1.2 RELATED REQUIREMENTS

Section 16050N, "Basic Electrical Materials and Methods" and Section 16081N, "Apparatus Inspection and Testing" apply to this section with additions and modifications specified herein.

1.2.1 Underground Service

Terminate underground service into building at a point 1525 mm 5 feet outside the building and projections thereof, except that service conductors shall be continuous to the interior terminating point indicated.

Connections of the service to the service entrance equipment is included in Section 16402N, "Interior Distribution System." Protect ends of underground conduit with threaded metal caps or plastic plugs as applicable until connections are made.

1.3 DEFINITIONS

- a. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.
- b. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.
- [c. Underground structures subject to aircraft loading are indicated on the drawings.]

NOTE: Areas subject to aircraft loading are generally defined as follows:

- 1. For fixed wing aircraft facilities:
 - a) On or within 200 feet 61 m of runway sideline
 - b) On or within 50 feet 15 m of taxiway or apron sideline
 - c) Within Type 1 clear zone area as defined by NAVFAC Publication P-971 "Airfield & Heliport Planning & Design" dated March 1998.
- 2. For rotary wing aircraft facilities:
 - a) On landing surfaces, primary surfaces, or within areas defined as "paved and unpaved shoulders" in NAVFAC Publication P-971 "Airfield & Heliport Planning & Design" dated March 1998.

1.4 SUBMITTALS

NOTE: Where a "G" in asterisk tokens follows a submittal item, it indicates Government approval for that item. Add "G" in asterisk tokens following any added or existing submittal items deemed sufficiently critical, complex, or aesthetically significant to merit approval by the Government. Submittal items not designated with a "G" will be approved by the CQC organization.

Submit the following in accordance with the Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Precast underground structures; G

Pulling-in irons; G

SD-03 Product Data

**NOTE: Submittals are required for each kind,
voltage, or type used on the project.**

Innerduct; G

Medium voltage cable; G

Medium voltage cable terminations; G

Medium voltage cable joints; G

[Live end caps; G]

Precast concrete structures; G

Sealing material for precast manhole and handhole joints; G

Manhole frames and covers; G

Handhole frames and covers; G

[Frames and Covers for Airfield Facilities; G]

[Ductile Iron Frames and Covers for Airfield Facilities; G]

Composite/fiberglass handholes; G

Cable supports (racks, arms and insulators); G

SD-06 Test Reports

Arc-proofing test for cable fireproofing materials; G

Medium voltage cable qualification and production tests; G

Field Acceptance Checks and Tests; G

Identify each cable for 600-volt, and medium voltage cable tests. When testing grounding electrodes and grounding systems, identify each grounding electrode and each grounding system for testing. Include the test method and test setup (i.e. pin locations) used to determine ground resistance and soil conditions at the time the measurements were made.

SD-07 Certificates

Cable splicer/terminator; G

1.5 QUALITY ASSURANCE

1.5.1 Precast Underground Structures

Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

- a. Material description (i.e., f'_c and F_y)
- b. Manufacturer's printed assembly and installation instructions
- c. Design calculations
- d. Reinforcing shop drawings prepared in accordance with ACI 315
- e. Plans and elevations showing opening and pulling-in iron locations and details

1.5.2 Certificate of Competency for Cable Splicer/Terminator

Certification of the qualification of the cable splicer/terminator shall be submitted, for approval, 30 days before splices or terminations are to be made in medium voltage (5 kV to 35 kV) cables. The certification shall include the training, and experience of the individual on the specific type and classification of cable to be provided under this contract. The certification shall indicate that the individual has had three or more years recent experience splicing and terminating medium voltage cables. The certification shall also list a minimum of three splices/terminations that have been in operation for more than one year. In addition, the individual may be required to perform a dummy or practice splice/termination in the presence of the Contracting Officer, before being approved as a qualified cable splicer. If that additional requirement is imposed, the Contractor shall provide short sections of the approved types of cables along with the approved type of splice/termination kit, and detailed manufacturer's instructions for the cable to be spliced. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for certification of an alternate cable splicer.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Conduit

2.1.1.1 Rigid Metal Conduit

UL 6, galvanized steel, threaded type.

2.1.1.2 Rigid Metal Conduit, PVC Coated

UL 6, galvanized steel, threaded type, coated with a polyvinyl chloride (PVC) sheath bonded to the galvanized exterior surface, nominal one millimeter 40 mils thick, conforming to NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A durometer, dielectric strength shall be minimum 15.75 kV per mm 400 volts per mil at 60 Hz, tensile strength shall be minimum 25 MPa 3500 psi, and aging shall be minimum 1000 hours in an Atlas Weatherometer.

2.1.1.3 Intermediate Metal Conduit

UL 1242, galvanized steel, threaded type.

2.1.1.4 Intermediate Metal Conduit, PVC Coated

UL 1242, galvanized steel, threaded type, coated with a polyvinyl chloride (PVC) sheath bonded to the galvanized exterior surface, nominal one millimeter 40 mils thick, conforming to NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A durometer, dielectric strength shall be minimum 15.75 kV per mm 400 volts per mil at 60 Hz, tensile strength shall be minimum 25 MPa 3500 psi, and aging shall be minimum 1000 hours in an Atlas Weatherometer.

2.1.1.5 Plastic Conduit for Direct Burial

**NOTE: Refer to NEMA TC 2 for EPC-40-PVC for general
underground direct burial use, and for EPC-80-PVC
where additional crushing or impact strength would
be appropriate.**

NEMA TC 2 and UL 651, Type [EPC-40-PVC] [or] [EPC-80-PVC] [as indicated].

2.1.1.6 Plastic Utilities Duct for Concrete Encasement

NEMA TC 6 & 8 and UL 651A, Type [EB] [or] [____] [as indicated].

2.1.2 Fittings

2.1.2.1 Metal Fittings

UL 514B, threaded type.

2.1.2.2 PVC Conduit Fittings

NEMA TC 3, UL 514B, and UL 651.

2.1.2.3 PVC Duct Fittings

NEMA TC 9.

2.1.2.4 Innerduct

Provide corrugated [or solid wall] polyethylene (PE) or PVC innerducts with pullwire. Size as indicated.

[2.1.2.5 Outlet Boxes for Steel Conduit

Outlet boxes for use with rigid or flexible steel conduit shall be cast-metal cadmium or zinc-coated if of ferrous metal with gasketed closures and shall conform to UL 514A.

]2.1.3 Conductors Rated 600 Volts and Less

Conductor sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors shall have

the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than [24] [12] months prior to date of delivery to the site shall not be accepted.

NOTE: Type THW insulation can only be obtained in large quantity. Use of this type of insulation is not recommended for smaller projects. Types USE and THW are larger than THWN insulation. When they are allowed ensure that the conduit has been properly sized for the number of THW or USE wires indicated in each conduit run.

2.1.3.1 Conductor Types and Color Coding

NOTE: If aluminum conductor is permitted (not excluded), include requirement for adjusting the raceway sizes with additional reference to NEC. Also give detailed instructions as to materials and methods required for splicing and terminating 600-volt wires and cables with regard to the material used at bus or other connection point. There are instances when you may want to consider copper only (customer request, matching existing with small quantity, etc.). If copper only is specified, delete item b in subparagraph entitled "Conductors rated 600 volts and less", and other references to aluminum conductors.

Service entrance and direct buried conductors shall conform to UL 854, Type USE. Conductors in conduit other than service entrance shall conform to UL 83, Type THWN [or THW]. Conductor size and number of conductors in each cable shall be as indicated. Conductors shall be color coded. Conductor identification shall be provided within each enclosure where a tap, splice, or termination is made. Conductor identification shall be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, or heat shrink type sleeves. Control circuit terminations shall be properly identified. Conductors No. 10 AWG and smaller shall be solid copper. Conductors No. 8 AWG and larger shall be stranded copper. [All conductors shall be copper.] [Conductors No. 6 AWG and smaller shall be copper. Conductors No. 4 AWG and larger shall be either copper or aluminum, at the Contractor's option.] [As an exception to the preceding statement, do not substitute aluminum for copper if the equivalent aluminum conductor size would exceed 500 kcmil.]

a. Colors for coding conductors shall be:

208-VOLT SYSTEM

Neutral - White
Phase A - Black
Phase B - Red
Phase C - Blue
Grounding Conductor - Green

480-VOLT SYSTEM

Neutral - White
Phase A - Brown
Phase B - Orange
Phase C - Yellow
Grounding Conductor - Green

- [b. Aluminum Conductors: Aluminum conductors shall be AA-8000 series electrical grade aluminum alloy. Type EC/1350 is not acceptable. Should the Contractor choose to use the aluminum option for conductors No. 4 AWG and larger diameter, the Contractor shall be responsible for increasing the conductor size to have the same ampacity as the copper size indicated; increasing the conduit and pull box sizes to accommodate larger size aluminum conductors in accordance with NFPA 70; ensuring that the pulling tension rating of the aluminum conductor is sufficient; relocating equipment, modifying equipment terminations, resizing equipment; and resolving to the satisfaction of the Contracting Officer interference problems that are direct results of the use of aluminum conductors in lieu of copper. Where Contractor provides equipment whose manufacturer requires copper conductors at the terminations, or requires that only copper conductors be provided between components of equipment, the Contractor shall provide copper conductors, or necessary splices, splice boxes, and other work required to satisfy manufacturer's requirements.]

2.1.4 600 Volt Wire Connectors and Terminals

Shall provide a uniform compression over the entire contact surface. Solderless terminal lugs shall be used on stranded conductors.

- a. For use with Copper Conductors: UL 486A.
- [b. For use with Aluminum Conductors: UL 486B. For connecting aluminum to copper, connectors shall be the circumferentially compressed, metallurgically bonded type.]

2.1.5 600 Volt Splices

Provide splices with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with NEMA C119.1.

- a. Provide cast-type splice insulation by means of molded casting process employing a thermosetting epoxy resin insulating material applied by a gravity poured method or by a pressure injected method. Provide component materials of the resin insulation in a packaged form ready for convenient mixing without removing from the package.
 - 1. Gravity poured method shall employ materials and equipment contained in an approved commercial splicing kit which includes a mold suitable for the cables to be spliced. When the mold is in place around the joined conductors, prepare the resin mix and pour into the mold.
- b. Provide [heavy wall] heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which shall be applied by a clean burning propane gas torch.
- c. Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation shall not require heat or flame, or any additional materials such as coverings or adhesive. It shall be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.1.6 Medium Voltage Cable

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors shall have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than [24] [12] months prior to date of delivery to the site shall not be accepted.

NOTE:

1. For EPR: Cable ratings and insulation thickness are shown in table C-1 of AEIC CS6. Jacket thickness is shown in table 7-3 of NEMA WC 74 and Table 27.18 of UL 1072.

For XLP: Cable ratings and insulation thickness are as calculated in AEIC CS8. Jacket thickness is shown in table 7-3 of NEMA WC 74 and Table 27.18 of UL 1072.

2. Require compact round conductors only where cable size is limited by the size of the conduit and where the conduit size cannot be increased to accommodate the conductors. Standard cable conductors provided by some manufacturers are compressed or compact round. These meet the requirements if compact round conductors or compressed conductors are not explicitly specified. In compact round conductors, the diameter of the stranded conductor is reduced by approximately 10 percent.

NOTE: For projects within LANTNAVFACENGCOM: Use only EPR insulation with a tape shield unless specifically requested by the activity, or otherwise directed, to use or allow the use of XLP insulation, or wire shield. Values for 133 percent insulation shall be used on all systems other than four-wire, multi-grounded systems, unless specifically directed otherwise. Use values in tables below for insulation thicknesses for single-conductor EPR cables.

INSULATION THICKNESS AND CONDUCTOR SIZES
(From AEIC CS6 Table C-1)

Rated Voltage Phase to Phase (kV)	Conductor Size (AWG or kcmil)	Minimum Average Insulation Thickness (mils) at	
		Insulation Level	
		<u>100%</u>	<u>133%</u>
5	8 to 1000	90	115
15	2 to 1000	175	220
35	1/0 to 2000	345	420

2.1.6.1 Cable Configuration

Cable for [34.5] [13.2] [12.47] [11.5] [4.16] [____] kV underground distribution system shall be Ozone resistant ethylene-propylene -rubber-insulated (EPR) cable conforming to NEMA WC 74, AEIC CS6, and UL 1072 [or cross-linked-thermosetting-polyethylene-insulated (XLP) cable conforming to NEMA WC 74, AEIC CS8, and UL 1072]. Cable shall be [single] [three] conductor, employing concentric-lay-stranded, Class B, [compact round,]copper conductors. Cable shall have conductor and insulation shielding. Insulation shielding shall be metal tape [or wire] type consisting of a concentric serving of tape [or wires] according to NEMA WC 74. Cable shall be rated [____] kV with insulation thickness of [____] mils. Cable shall have a polyvinyl chloride jacket with thickness conforming to NEMA WC 74 and UL 1072.

[2.1.6.2 Paper Insulated Lead Covered (PILC) Cables

NOTE: PILC cables for use on circuits 10 kV or more shall be shielded. PILC cable is recommended only for projects where new cable system will be spliced to existing PILC cable distribution system.

Cable for [34.5] [13.2] [12.47] [11.5] [4.16] kV distribution system shall be solid type impregnated-paper-insulated lead-covered cable conforming to AEIC CS1. Cable shall be [single] [three] conductor, employing concentric-lay-stranded, Class B, [compact round,] copper conductor[s]. The cable shall have conductor shielding and insulation shielding over each individual conductor. The sheath shall be of the finest approved special fatigue resistant, age resistant arsenical lead alloy proved by experience and bending machine tests. The sheath shall be smooth and concentric, free of scars or indentations. The thickness of the sheath shall be in accordance with AEIC CS1. Any samples exceeding the specified thickness deviations at any point shall justify complete rejection of adjacent cable without further tests or qualifications. A protective covering of thermoplastic polyethylene shall be applied over the sheath. The rated voltage of the cable shall be [____] kV [[____] percent insulation level for [____] kV system].

]2.1.7 Medium Voltage Cable Terminations

IEEE 48 Class 1. Provide terminations for indoor or outdoor use which include stress control terminator with skirts, ground clamp, connectors, and lugs. The terminator shall be the product of one manufacturer, suitable for the type and materials of the cable terminated. Furnish components in the form of a "UL listed" kit, including complete instructions which shall be followed for assembly and installation. Provide terminator as specified herein for terminating single conductor, [or the single conductor of multiconductor,] solid insulated, nonmetallic jacketed type cables for service voltage up to 35 kV. Do not use separate parts of copper or copper alloy in contact with aluminum or aluminum alloy parts in the construction or installation of the terminator.

NOTE: Provide with skirts. By including skirts for "indoor" and "within equipment" locations, tracking

resistance is significantly improved.

2.1.7.1 Cold-Shrink Type

Terminator shall be a one-piece design utilizing the manufacturer's latest technology, where high-dielectric constant (capacitive) stress control is integrated within a skirted insulator made of silicone rubber. Termination shall not require heat or flame for installation. Termination kit shall contain all necessary materials (except for the lugs). Termination shall be designed for installation in low or highly contaminated indoor or outdoor locations and shall resist ultraviolet rays and oxidative decomposition.

2.1.7.2 Heat Shrinkable Type

Terminator shall consist of a uniform cross section heat shrinkable polymeric and elastomeric construction stress relief tubing and environmentally sealed outer covering that is nontracking, resists heavy atmospheric contaminants, ultra violet rays and oxidative decomposition. Provide heat shrinkable sheds or skirts of the same material. Termination shall be designed for installation in low or highly contaminated indoor or outdoor locations.

[2.1.8 Termination; Separable Insulated Connector Type

NOTE: Separable insulated connectors, such as load-break elbows, may be used with certain equipment. Where they are required, they should be specified in the section that provides the equipment (i.e., Sections 16272N, 16273N, and 16341N) and cross referenced herein for installation and testing.

Provide as specified in Section [16272N, "Three-Phase Pad-Mounted Transformers"] [16273N, "Single-Phase Pad-Mounted Transformers"] [and] [16341N, "SF6 Insulated Pad-Mounted Switchgear"].

]2.1.9 Medium Voltage Cable Joints

Provide joints (splices) in accordance with IEEE 404 suitable for the rated voltage, insulation level, and insulation type of the cable. Upon request, supply manufacturer's design qualification test report in accordance with IEEE 404. Connectors for joint shall be tin-plated electrolytic copper, having ends tapered and having center stops to equalize cable insertion. Connectors shall be rated for voltage of 35 kV minimum.

- a. Heat-Shrinkable Joint: Consists of a uniform cross-section heat-shrinkable polymeric construction with a linear stress relief system, a high dielectric strength insulating material, and an integrally bonded outer conductor layer for shielding. Replace original cable jacket with a heavy-wall heat-shrinkable sleeve with [hot-melt adhesive coating.] [waterproof mastic seal on both ends.]
- b. Watertight Taped-Type Joint: Consists of an approved connector, self-fusing or self-bonding insulating tape, self-fusing semiconducting tape, tinned copper shielding tape or braid, and plastic tape.

- c. Cold-shrink rubber-type joint: Joint shall be of a cold shrink design that does not require any heat source for its installation. Splice insulation and jacket shall be of factory formed cold shrink sleeves made of black EPDM rubber. Splice shall be packaged three splices per kit, including complete installation instructions.

[2.1.10 Live End Caps

Provide live end caps using a "kit" including a heat-shrinkable or cold-shrink tube and a high dielectric strength, polymeric plug overlapping the conductor. End cap shall conform to applicable portions of IEEE 48.

]2.1.11 Tape

2.1.11.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.1.11.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 02315N, "Excavation and Fill".

2.1.11.3 Fireproofing Tape

NOTE: Provide the following paragraph where medium voltage cable (2200 volts or greater) is installed in manholes, handholes and vaults.

Furnish tape composed of a flexible conformable unsupported intumescent elastomer. Tape shall be not less than 0.762 mm 0.030 inch thick by 76.2 mm 3 inches wide, noncorrosive to cable sheath, self-extinguishing, noncombustible, and shall not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.1.12 Pull Rope

Shall be plastic having a minimum tensile strength of 890 N 200 pounds.

2.1.13 Grounding and Bonding Equipment

NOTE: Provide 20 foot sectional ground rods on projects at the Naval Hospital in Portsmouth, Virginia.

UL 467. Provide copper clad steel ground rods with diameter adequate to permit driving to full length of the rod, but not less than 19 mm 3/4 inch in diameter. Ground rods shall be[3050 mm 10 feet long][6100 mm 20 feet long, sectional type] unless otherwise indicated.

2.1.14 Cast-In-Place Concrete

NOTE: Use the first bracketed paragraph when

project includes a concrete section in Division 3;
otherwise, the second bracketed paragraph may be
used. Coordinate requirements with Section 03300,
"Cast-in-Place Concrete."

[Concrete for encasement of underground ducts shall be 20 MPa 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts shall be 30 MPa 4000 psi minimum 28-day compressive strength unless specified otherwise. All concrete shall conform to the requirements of Section 03300, "Cast-in-Place Concrete."]

NOTE: If concrete requirements are detailed and no cast-in-place concrete section is to be included in the project specification, refer to Section 03300, "Cast-in-Place Concrete," and select such portions as needed to provide complete requirements in addition to the requirements below.

[Shall be composed of fine aggregate, coarse aggregate, portland cement, and water so proportioned and mixed as to produce a plastic, workable mixture. Fine aggregate shall be of hard, dense, durable, clean, and uncoated sand. The coarse aggregate shall be reasonably well graded from 4.75 mm to 25 mm 3/16 inch to one inch. The fine and coarse aggregates shall be free from injurious amounts of dirt, vegetable matter, soft fragments or other deleterious substances. Water shall be fresh, clean, and free from salts, alkali, organic matter, and other impurities. Concrete for encasement of underground ducts shall be 20 MPa 3000 psi minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts shall be 30 MPa 4000 psi minimum 28-day compressive strength unless specified otherwise. Slump shall not exceed 100 mm 4 inches. Retempering of concrete will not be permitted. Exposed, unformed concrete surfaces shall be given a smooth, wood float finish. Concrete shall be cured for a period of not less than 7 days, and concrete made with high early strength portland cement shall be repaired by patching honeycombed or otherwise defective areas with cement mortar as directed by the Contracting Officer. Air entrain concrete exposed to weather using an air-entraining admixture conforming to ASTM C260. Air content shall be between 4 and 6 percent.]

2.1.15 Underground Structures

NOTE: This paragraph should be edited to comply with project requirements concerning the type of structure or duct, strength of concrete, concrete mix, metal accessories, and excavating and grading. Indicate special reinforcing where required, particularly with duct banks of non-rectangular cross-section. Designer shall contact local telephone company, where applicable, concerning the size of all signal manholes and the number and type of signal duct required. Determine availability since aircraft or H2O highway loadings may not be available in precast.

See standard sketches UG-1 through UG-7, covering
manholes and handholes located at
http://www.efdlant.navfac.navy.mil/lantops_04/home.htm.

The required sketches should be included on the
project drawings.

Provide precast concrete underground structures or standard type cast-in-place [manhole] [and] [handhole] types as indicated, conforming to ASTM C857 and ASTM C478M ASTM C478[, except that the spacing of manhole steps or ladder rungs shall not exceed 405 mm 16 inches]. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, shall be adequate to accommodate the cable.

2.1.15.1 Cast-In-Place Concrete Structures

Concrete shall conform to Section 03300, "Cast-in-Place Concrete."
[Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers].
[Concrete block shall conform to ASTM C139 and Section 04200N, "Unit Masonry."] [Concrete block is not allowed in areas subject to aircraft loading.] [Decks and covers subject to aircraft loading shall be as indicated on the drawings.]

2.1.15.2 Precast Concrete Manholes, Risers and Tops

In lieu of cast-in-place, Contractors, at their option, may provide precast concrete underground structures subject to the requirements specified below. Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes and handholes.

- a. General: Precast concrete structures shall have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures shall have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction shall be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work shall have a 28-day compressive strength of not less than 30 MPa 4000 psi. Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures shall be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.
- b. Design for Precast Structures: ACI 318M/318RM. In the absence of detailed on-site soil information, design for the following soil

parameters/site conditions:

1. Angle of Internal Friction (ϕ) = 0.523 rad 30 degrees
2. Unit Weight of Soil (Dry) = 1760 kg/m³ 110 pcf, (Saturated)
= 2080 kg/m³ 130 pcf
3. Coefficient of Lateral Earth Pressure (K_a) = 0.33
4. Ground Water Level = 915 mm 3 feet below ground elevation

NOTE: Specify H20 highway loading for most locations. Revise as required if loading in excess of H20 highway loading is required.

Use the second bracketed option for structures that may be subject to aircraft loading. Structures subject to aircraft loading shall be as indicated on the drawings. Structure design requirements must also be shown on the drawings. Decks and covers subject to aircraft loadings shall be designed for loadings per FAA AC-150/5320-6 except as follows:

- a. Covers shall be designed for 100,000 lb 45 000 kg wheel loads with 250 psi 1.72 MPa tire pressure.
- b. For spans of less than 2 feet 0.6 m in the least direction, a uniform live load of 325 psi 2.24 Mpa shall be used.
- c. For spans of 2 feet 0.6 m or greater in the least direction, the design shall be based on the number of wheels which will fit the span. Wheel loads of 75,000 pounds 34,000 kg each shall be used.

5. Vertical design loads shall include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads shall consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered.[The minimum design vertical load shall be for H20 highway loading per AASHTO HB.][Decks and covers subject to aircraft loading shall be as indicated on the drawings.]
6. Horizontal design loads shall include full geostatic and hydrostatic pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, shall be considered, along with a pulling-in iron design load of 26,700 N 6000 pounds.
7. Each structural component shall be designed for the load combination and positioning resulting in the maximum shear and moment for that particular component.
8. Design shall also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting

devices to ensure structural integrity during handling and installation.

- c. Construction: Structure top, bottom, and wall shall be of a uniform thickness of not less than 150 mm 6 inches. Thin-walled knock-out panels for designed or future duct bank entrances shall not be permitted. Quantity, size, and location of duct bank entrance windows shall be as directed, and cast completely open by the precaster. Size of windows shall exceed the nominal duct bank envelope dimensions by at least 305 mm 12 inches vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows shall be a minimum of 150 mm 6 inches from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. [The minimum concrete cover for reinforcing steel shall be 50 mm 2 inches.] Provide drain sumps a minimum of 305 mm 12 inches in diameter and 100 mm 4 inches deep for precast structures.

NOTE: Do not use shiplap joints for
LANTNAVFACENGCOM projects.

- d. Joints: Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to AASHTO M198, Type B. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.1.15.3 Manhole Frames and Covers

Provide cast iron frames and covers for manholes conforming to CID A-A-60005. Cast the words "ELECTRIC" and "TELEPHONE" in the top face of power and telephone manhole covers, respectively.

2.1.15.4 Handhole frames and covers

Frames and covers of steel shall be welded by qualified welders in accordance with standard commercial practice. Steel covers shall be rolled-steel floor plate having an approved antislip surface. Hinges shall be of [stainless steel with bronze hinge pin] [wrought steel], 125 by 125 mm 5 by 5 inches by approximately 4.75 mm 3/16 inch thick, without screw holes, and shall be for full surface application by fillet welding. Hinges shall have nonremovable pins and five knuckles. The surfaces of plates under hinges shall be true after the removal of raised antislip surface, by grinding or other approved method.

[2.1.15.5 Frames and Covers for Airfield Facilities

NOTE: Use this paragraph for structures subject to aircraft loading.

Fabricate frames and covers for airfield use of standard commercial grade steel welded by qualified welders in accordance with AWS D1.1/D1.1M. Covers shall be of rolled steel floor plate having an approved anti-slip surface. Steel frames and covers shall be hot dipped galvanized after fabrication.

]2.1.15.6 Ductile Iron Frames and Covers for Airfield Facilities

NOTE: As an option, the designer may also allow the use of this paragraph for structures subject to aircraft loading.

At the contractor's option, ductile iron covers and frames designed for a minimum proof load of 100,000 pounds 45,000 kg, may be provided in lieu of the steel frames and covers indicated. Covers shall be of the same material as the frames (i.e. ductile iron frame with ductile iron cover, galvanized steel frame with galvanized steel cover). Proof loading shall be performed in accordance with CID A-A-60005 and ASTM A48/A48M. Proof loads shall be physically stamped into the cover. Provide the Contracting Officer copies of previous proof load test results performed on the same frames and covers as proposed for this contract. The top of the structure shall be modified to accept the ductile iron structure in lieu of the steel structure indicated. The finished structure shall be level and non-rocking, with the top flush with the surrounding pavement.

]2.1.15.7 Brick for Manhole Collar

NOTE: Do not use brick for manholes in Iceland.

Brick shall be sewer and manhole brick conforming to ASTM C32, Grade MS.

]2.1.16 Composite/Fiberglass Handholes and Covers

Provide handholes and covers as indicated. Handholes and covers shall be of polymer concrete, reinforced with heavy weave fiberglass.

2.1.17 Cable Supports (Racks, Arms and Insulators)

The metal portion of racks and arms shall be zinc-coated after fabrication.

2.1.17.1 Cable Racks

The wall bracket shall be 100 mm 4 inches by approximately 38 mm by 4.76 mm 1-1/2 inch by 3/16 inch channel steel, [1220 mm 48 inches long (minimum) in manholes] [and] [[____] mm inches long in handholes]. Slots for mounting cable rack arms shall be spaced at 200 mm 8 inch intervals.

2.1.17.2 Rack Arms

Cable rack arms shall be steel or malleable iron or glass reinforced nylon and shall be of the removable type. Rack arm length shall be a minimum of

200 mm 8 inches and a maximum of 305 mm 12 inches.

2.1.17.3 Insulators

Insulators for metal rack arms shall be dry-process glazed porcelain. Insulators are not required for nylon arms.

2.1.18 Cable Tags

Provide as specified in 16050N, "Basic Electrical Materials and Methods."

2.2 SOURCE QUALITY CONTROL

2.2.1 Arc-Proofing Test for Cable Fireproofing Materials

Manufacturer shall test [one] [three] sample [assembly] [assemblies, each] consisting of a straight lead tube 305 mm 12 inches long with a 65.5 mm 2 1/2-inch outside diameter, and a 3.175 mm 0.125 inch thick wall, and covered with one-half lap layer of arc and fireproofing material per manufacturer's instructions. The arc and fireproofing tape shall withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode shall be obtained from a DC power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc shall be directed toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly shall be tested at three unrelated points. Start time for tests shall be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time shall be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape shall indicate that the test has been performed and passed by the manufacturer.

2.2.2 Medium Voltage Cable Qualification and Production Tests

NOTE: Use AEIC CS6 for EPR cable and AEIC CS8 for XLP cable.

Results of [AEIC CS6] [AEIC CS8] qualification and production tests as applicable for each type of medium voltage cable.

PART 3 EXECUTION

3.1 INSTALLATION

NOTE: Soil treatment for termite control shall conform to Section 02361N, "Soil Treatment for Termite Control," except that application to direct burial cable installation shall be as specified. In lieu of soil poisoning, cable in direct-buried EPC-40-PVC conduit can be a more economical and practical way of protecting cable from termites.

Underground installation shall conform to IEEE C2 and NFPA 70 except as otherwise specified or indicated.

3.1.1 Contractor Damage

The Contractor shall promptly repair any indicated utility lines or systems damaged by Contractor operations. Damage to lines or systems not indicated, which are caused by Contractor operations, shall be treated as "Changes" under the terms of the General Provisions of the contract. If the Contractor is advised in writing of the location of a nonindicated line or system, such notice shall provide that portion of the line or system with "indicated" status in determining liability for damages. Nonindicated utility lines found by the Contractor while scanning the construction site with electromagnetic or sonic tracing equipment will be treated as "indicated" utilities. In any event, the Contractor shall immediately notify the Contracting Officer of any such damage.

3.1.2 Cast-In-Place Concrete

NOTE: Use the first bracketed option when project includes a concrete section in Division 3; otherwise, the second bracketed option may be used.

Cast-in-place concrete work shall conform to the requirements of [Section 03300, "Cast-in-Place Concrete"] [ACI 318M/318RM].

3.1.3 Direct Burial System

NOTE: Direct earth burial cables generally require direct burial splices. Observe marker slab requirements previously covered in this specification.

Bury cables directly in earth, except under [railroad tracks,] [paved areas,] [and] [roadways,] install cables in conduit encased in concrete. Install cables buried directly in earth in the following manner:

- a. Slope ducts to drain.
- b. Excavate trenches in which the cables are placed by hand or with mechanical trenching equipment, and provide a minimum cable cover of 610 mm 24 inches below finished grade for power conductors operated at 600 volts and less, and 765 mm 30 inches to the top of the cables for over 600 volts. Trenches shall be not less than [150] [200] mm [6] [8] inches wide, and shall be in straight lines between cable markers. [Cable plows shall not be used.] Bends in trenches shall have a radius of not less than 915 mm 36 inches. Where two or more cables are laid parallel in the same trench, space cables laterally at not less than 75 mm 3 inches apart, except that communication cable shall be separated from power cable by a minimum distance of 305 mm 12 inches.
- c. Do not unreel and pull cables into the trench from one end. However, the cable [may] [shall] be unreeled on grade and lifted into position. [Cable bedding and cover shall consist of material which would pass a 6

mm 1/4 inch screen with no sharp objects. When rock is encountered, remove to a depth of at least 75 mm 3 inches below the cable and fill the space with sand or clean earth free from particles larger than 6 mm 1/4 inch.][Cable bedding and cover shall consist of a 75 mm 3 inch sand bedding with 75 mm 3 inches more sand placed on top of cable.]

3.1.3.1 Restoration

Replace sod which has been removed, as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, pad construction, and other work to original condition and maintain until final acceptance. Provide necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging or mulching. [Perform work in accordance with Section 02921N, "Turf," and Section 02930N, "Exterior Plants."]

3.1.3.2 Crossing Cables

Separate cables crossing other cables or metal piping from the other cables or pipe by not less than [75] [305] mm [3] [12] inches of well tamped earth.

3.1.3.3 Splicing

Provide cables in one piece without splices between connections except where the distance exceeds the lengths in which cables are manufactured.

3.1.3.4 Bends

Bends in cables shall have an inner radius not less than [those specified in NFPA 70 for the type of cable specified.] [12 times the cable diameter.]

3.1.3.5 Horizontal Slack

Leave approximately 915 mm 3 feet of horizontal slack in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought above ground. Where cable is brought above ground, leave additional slack to make necessary connections.[Splices in lead-sheathed or armored cables shall be enclosed in split-type cast-iron splice boxes; after completion of the connection, tightly clamp the box and fill with insulating filler compound.]

3.1.4 Identification Slabs [Markers]

**NOTE: Use this paragraph for direct buried cable and
for direct buried conduit, to mark ends of conduit
sleeves under paved areas and to mark location of
stubouts.**

Provide a slab at each change of direction of direct buried cable, over each splice, over the ends of ducts or conduits which are installed under paved areas and roadways, and over ends of stubouts. Identification slabs shall be concrete, approximately 500 mm square by 150 mm 20 inches square by 6 inches thick and shall be set flat in the ground so that the top surface projects not less than 20 mm 3/4 inch, nor more than 30 mm 1 1/4 inches above ground. The concrete shall have a compressive strength of not less than 20 MPa 3000 psi and have a smooth troweled finish on exposed surface. Inscribe an identifying legend such as "electric cable," "telephone cable," "splice," or other applicable designation on the top

surface of the slab before concrete hardens. Inscribe circuit identification symbols on slabs as directed. Letters or figures shall be approximately 50 mm 2 inches high and grooves shall be approximately 6 mm 1/4 inch in width and depth. Install slabs so that the side nearest the inscription on top shall include an arrow indicating the side nearest the cable.

3.1.5 Underground Conduit/Duct Without Concrete Encasement

The type of conduit shall be [EPC-40-PVC,] [EPC-80-PVC,] [PVC-coated rigid metal conduit,] [PVC-coated intermediate metal conduit,] [rigid metal conduit,] [intermediate metal conduit,] [or] [rigid metal conduit field wrapped with 0.254 mm 0.010 inch thick pressure-sensitive plastic tape applied with a 50 percent overlap].

3.1.5.1 Conduit Installation

The top of the conduit shall be not less than 610 mm 24 inches below grade, and shall have a minimum slope of 75 mm 3 inches in each 30 meters 100 feet away from buildings and toward manholes and other necessary drainage points. Run conduit in straight lines except where a change of direction is necessary. Terminate conduits in end-bells where they enter underground structures. As each conduit run is completed, draw a nonflexible testing mandrel not less than 305 mm 12 inches long with a diameter 6 mm 1/4 inch less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. Provide not less than 75 mm 3 inches clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 75 mm 3 inches, fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 6 mm 1/4 inch sieve.

3.1.5.2 Encasement Under Roads and Structures

Under roads, paved areas, and railroad tracks, install conduits in concrete encasement of rectangular cross-section providing a minimum of 75 mm 3 inch concrete cover around ducts. The concrete encasement shall extend at least 1525 mm 5 feet beyond the edges of paved areas and roads, and 3660 mm 12 feet beyond the rails on each side of railroad tracks. Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, shall be zinc-coated, rigid steel, jacked into place. [Hydraulic jet method shall not be used.]

3.1.5.3 Multiple Conduits

Separate multiple conduits by a minimum distance of 50 mm 2 inches, except that light and power conduits shall be separated from control, signal, and telephone conduits by a minimum distance of 75 mm 3 inches. Stagger the joints of the conduits by rows and layers to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, and top spacers to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 3050 mm 10 feet of conduit assembly.

3.1.6 Underground Duct with Concrete Encasement

NOTE: Edit this paragraph to comply with project requirements concerning the type of structure or duct, strength of concrete, concrete mix, metal accessories, and excavating and grading. Indicate special reinforcing where required, particularly with duct banks of non-rectangular cross-section. Designer shall contact local telephone company, where applicable, concerning the size of signal manholes and the number and type of signal duct required. Medium voltage cables and campus distribution cables of the telecommunications backbone distribution system shall be in duct encased in concrete, unless otherwise required by local Activity. If so, indicate otherwise on drawings and edit last sentence.

Construct underground duct banks of individual conduits encased in concrete. Except where rigid galvanized steel conduit is indicated or specified, the conduit shall be PVC, Type EB. Do not mix different kinds or sizes of conduit in any one duct bank, except that power conduits may differ in size from telecommunications conduits. Ducts shall be a minimum of [100] [125] mm [4] [5] inches in diameter unless otherwise indicated. The concrete encasement surrounding the bank shall be rectangular in cross-section and shall provide at least 75 mm 3 inches of concrete cover around ducts. Separate conduits by a minimum concrete thickness of [50] [65] mm [2] [2 1\2] inches, except separate power conduits from telecommunications conduits by a minimum concrete thickness of 75 mm 3 inches. For all segments of power duct lines between manholes, provide a 4/0 AWG bare copper grounding conductor in the bottom of the open trench. Extend the conductor into each manhole. Provide duct encased in concrete for medium voltage cables and campus distribution cables of the telecommunications backbone distribution system, unless otherwise indicated.

3.1.6.1 Depth of Encasement

The top of the concrete envelope shall be a minimum of 450 mm 18 inches below grade[, except under roads and pavement, concrete envelope shall be a minimum of 610 mm 24 inches below grade] [and under railroad tracks a minimum of 1270 mm 50 inches below the top of the rails].

3.1.6.2 Slope of Encasement

Duct banks shall have a continuous slope downward toward underground structures and away from buildings with a minimum pitch of 75 mm in 30 meters 3 inches in 100 feet. Except at conduit risers, changes in direction of runs exceeding a total of 0.175 rad 10 degrees, either vertical or horizontal, shall be accomplished by long sweep bends having a minimum radius of curvature of 7.62 meters 25 feet; sweep bends may be composed of one or more curved or straight sections or combinations thereof. Manufactured bends shall have a minimum radius of 455 mm 18 inches for use with conduits of less than 75 mm 3 inches in diameter and a minimum radius of 915 mm 36 inches for ducts of 75mm 3 inches in diameter and larger. Excavate trenches along straight lines from structure to structure before ducts are laid or structure constructed so the elevation can be adjusted, if necessary, to avoid unseen obstruction.

3.1.6.3 Conduit

Terminate conduits in end-bells where ducts enter underground structures. Stagger the joints of the conduits by rows and layers to strengthen the duct bank. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, and top spacers to provide a completely enclosed and locked-in duct bank. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 3050 mm 10 feet of duct bank. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring shall be done by driving reinforcing rods adjacent to every other duct spacer assembly and attaching the rod to the spacer assembly.

3.1.6.4 Test Mandrel

As each section of a duct bank is completed from structure to structure, a testing mandrel not less than 305 mm 12 inches long with a diameter 6 mm 1/4 inch less than the inside diameter of the conduit shall be drawn through each conduit, after which a stiff-bristled brush, having the diameter of the conduit shall be drawn through until the conduit is clear of earth, sand, and gravel particles. Conduit plugs shall then be immediately installed.

3.1.6.5 Connections to Manholes

Duct bank envelopes connecting to underground structures shall be flared to have an enlarged cross-section at the manhole entrance to provide additional shear strength. The dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 305 mm 12 inches in each direction. The perimeter of the duct bank opening in the underground structure shall be flared toward the inside or keyed to provide for a positive interlock between the duct bank and the wall of the structure. Vibrators shall be used when this portion of the envelope is poured to assure a seal between the envelope and the wall of the structure.

3.1.6.6 Connections to Existing Underground Structures

NOTE: Most duct banks do not have reinforcing steel, therefore the first option should be selected. Use the second option only for duct banks with reinforcing steel.

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve the steel in the structure wall. Cut the steel and [extend into] [bend out to tie into the reinforcing of] the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

3.1.6.7 Connections to Existing Concrete Pads

NOTE: Most duct banks do not have reinforcing steel, therefore the first option should be selected. Use the second option only for duct banks

with reinforcing steel.

For duct bank connections to concrete pads, break an opening in the pad out to the dimensions required and preserve the steel in the pad. Cut the steel and [extend into] [bend out to tie into the reinforcing of] the duct bank envelope. Chip out the opening in the pad to form a key for the duct bank envelope.

3.1.6.8 Connections to Existing Ducts

Where connections to existing duct banks are indicated, excavate the banks to the maximum depth necessary. The banks shall be cut off and loose concrete removed from the conduits before new concrete-encased ducts are installed. A reinforced concrete collar, poured monolithically with the new duct bank, shall be provided to take the shear at the joint of the duct banks.[Remove existing cables which constitute interference with the work.][Abandon in place the unused ducts and cables which do not interfere with the work.]

3.1.6.9 Partially Completed Duct Banks

During construction wherever a construction joint is necessary in a duct bank, prevent debris such as mud, sand, and dirt from entering ducts by providing suitable conduit plugs. Fit concrete envelope of a partially completed duct bank with reinforcing steel extending a minimum of 610 mm 2 feet back into the envelope and a minimum of 610 mm 2 feet beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm 3 inches from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 305 mm 1 foot apart. Restrain reinforcing assembly from moving during concrete pouring.

3.1.7 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty shall be provided with plugs on each end. Plugs shall contain a weep hole or screen to allow water drainage. Provide a plastic pull rope having 915 mm 3 feet of slack at each end of unused or empty conduits.

3.1.8 Innerducts

Installation shall be as per manufacturer's instructions.

[3.1.9 Removal of Ducts

Where duct banks are removed from existing underground structures, close the openings to waterproof the structure. Chip out the wall opening to provide a key for the new section of wall.

]3.1.10 Underground Conduit for Service Feeders Into Buildings

Shall be PVC, Type EPC-40, galvanized rigid steel, or steel IMC from the service equipment to a point 1525 mm 5 feet beyond the building and projections thereof. Protect the ends of the conduit. Provide threaded metal caps or bushings for metal conduit, and coat the threads with graphite grease or other coating. Clean and plug conduit until conductors are installed. Encase the underground portion of the conduit in a concrete envelope and bury as specified for underground duct with concrete encasement.

3.1.11 Conduit Protection at Concrete Penetrations

Galvanized conduits which penetrate concrete (slabs, pavement, and walls) shall be PVC coated and shall extend from the first coupling or fitting outside either side of the concrete (minimum of 150 mm 6 inches from penetration).

3.1.12 Installation of Warning and Identification Tape

Provide warning tape for underground direct buried, in conduit, and concrete encased systems. Bury tape with the printed side up at a depth of 305 mm 12 inches below the top surface of earth or the top surface of the subgrade under pavements.

3.1.13 Underground Structure Construction

NOTE: This paragraph should be edited to comply with project requirements concerning the type of structure, strength of concrete, concrete mix, metal accessories, and excavating and grading. Indicate special reinforcing where required. Designer shall contact local telephone company, where applicable, concerning the size of all signal manholes and the number and type of signal duct required. Determine availability since H2O or aircraft loadings may not be available in precast.

See standard sketches UG-1 through UG-7 covering manholes and handholes. The required sketches should be included on the project drawings. These sketches can be found at http://www.efdlant.navfac.navy.mil/lantops_04/home.htm.

Underground structures shall be of standard type cast in place construction as specified herein and as indicated, or may be of precast construction as specified herein. Horizontal concrete surfaces of floors shall have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound shall conform to ASTM C309. Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete.

3.1.13.1 Precast Concrete Construction

Commercial precast structures shall be set on 150 mm 6 inches of level, 90 percent compacted granular fill, 19 mm to 25 mm 3/4 inch to 1 inch size, extending 305 mm 12 inches beyond the structure on each side. Granular fill shall be compacted by a minimum of four passes with a plate type

vibrator. Installation shall additionally conform to the manufacturer's instructions.

3.1.13.2 Pulling-In Irons

Pulling-in irons shall be steel bars bent as indicated, and cast in the walls and floors. Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices shall be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor the irons shall be a minimum of 150 mm 6 inches from the edge of the sump, and in the walls the irons shall be located within 150 mm 6 inches of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron shall not be located within 150 mm 6 inches of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 150 mm 6 inch clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 915 mm 3 foot length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner shall be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 75 mm 3 inches from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons shall have a clear projection into the structure of approximately 100 mm 4 inches and shall be designed to withstand a minimum pulling-in load of 26,700 N 6000 pounds. Irons shall be [hot-dipped galvanized] [zinc-coated] after fabrication.

3.1.13.3 Cable Racks, Arms and Insulators

Cable racks, arms and insulators shall be sufficient to accommodate the cables. Racks in power manholes [and handholes] shall be spaced not more than 915 mm 3 feet apart, and each manhole [and handhole] wall shall be provided with a minimum of two racks. Racks in signal manholes [and handholes] shall be spaced not more than 420 mm 16 1/2 inches apart with the end rack being no further than 305 mm 12 inches from the adjacent wall.

Methods of anchoring cable racks shall be as follows:

- a. Provide a 15 mm diameter by 125 mm 5/8 inch diameter by 5 inch long anchor bolt with 75 mm 3 inch foot cast in structure wall with 50 mm 2 inch protrusion of threaded portion of bolt into structure. Provide 15 mm 5/8 inch steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts.
- b. Provide concrete channel insert with a minimum load rating of 1192 kg per meter 800 pounds per foot. Insert channel shall be steel of the same length as "vertical rack channel;" channel insert shall be cast flush in structure wall. Provide 15 mm 5/8 inch steel nuts in channel insert to receive 15 mm diameter by 75 mm 5/8 inch diameter by 3 inch long steel, square head anchor bolts.
- c. Provide concrete "spot insert" at each anchor bolt location, cast flush

in structure wall. Each insert shall have minimum 365 kg 800 pound load rating. Provide 15 mm diameter by 75 mm 5/8 inch diameter by 3 inch long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.1.13.4 Field Painting

**NOTE: Edit to match products contained in Part 2.
Choose cast-iron for most applications. Ductile
iron or steel may be required for areas subject to
heavy loading such as airfields or industrial areas.**

[[Cast-iron frames and covers] [and] [ductile iron frames and covers] not buried in concrete or masonry shall be cleaned of mortar, rust, grease, dirt and other deleterious materials, and given a coat of bituminous paint.] [Steel frames not buried in masonry and steel covers shall be cleaned. Steel surfaces contaminated with rust, dirt, or similar materials shall be cleaned to bare metal by wire brushing or other mechanical means in accordance with SSPC SP 2 and SSPC SP 3. Steel surfaces contaminated with oil, grease, or other similar contaminants shall be washed with solvents in accordance with SSPC SP 1. As soon as practicable after the cleaning, surfaces shall be primed with a coat of marine alkyd metal primer in accordance with MPI 79 and top coated with two coats of exterior alkyd, semi-gloss enamel in accordance with MPI 94.]

3.1.14 Composite/Fiberglass Handhole Installation

Install as indicated and in accordance with the manufacturer's instructions.

3.1.15 Cable Pulling

[Test existing ducts with a mandrel and thoroughly swab out to remove foreign material before pulling cables.] Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape [or wire] shield shall have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.1.15.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.1.15.2 Cable Pulling Tensions

Tensions shall not exceed the maximum pulling tension recommended by the cable manufacturer.

3.1.15.3 Installation of Cables in Underground Structures

NOTE: On contracts where existing cables are recircuited special attention should be given to changing existing cable identification tags in each manhole to reflect new circuit numbers.

Do not install cables utilizing the shortest path, but route along those walls providing the longest path and the maximum spare cable lengths. Form cables to closely parallel walls, without interference to duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

In existing manholes, handholes and vaults where new ducts are to be terminated or where new cables are to be installed, modify the existing installation of cables, cable supports and grounding as required for a uniform installation with cables carefully arranged and supported in the same manner as specified for new cables. [Provide [_____] cable racks in each existing underground structure through which cable is run.]

3.1.15.4 Cable Markers (or Tags) in Underground Structures

Provide as specified in Section 16050N, "Basic Electrical Materials and Methods."

[3.1.15.5 Conductors Installed in Parallel

Conductors shall be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor, 1 Phase C conductor, and 1 neutral conductor. Deviations may only be made in accordance with NFPA 70.

]3.1.16 600 Volt Cable Splicing and Terminating

NOTE: Direct earth burial cables generally require direct burial splices. Incorporate marker slab requirements previously covered in this specification.

Provide splices and terminations to protect 600 volt insulated power and lighting cables from accidental contact, deterioration of coverings and moisture. Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. [Make splices in underground distribution systems only in accessible locations such as manholes and handholes.]

[3.1.16.1 Terminating Aluminum Conductors

- a. Use particular care in making up joints and terminations. Remove surface oxides by cleaning with a wire brush or emery cloth. Apply joint compound to conductors, and use UL-listed solid aluminum connectors for connecting aluminum to aluminum conductors. When connecting aluminum to copper conductors, use connectors specifically designed for this purpose.

- b. Terminate aluminum conductors to copper bus either by: (1) in line splicing a copper pigtail to the aluminum conductor (copper pigtail shall have an ampacity at least that of the aluminum conductor); or (2) using a circumferential compression type, aluminum bodied terminal lug UL listed for AL/CU and steel Belleville spring washers, flat washers, bolts, and nuts. Belleville spring washers shall be cadmium-plated hardened steel. Install the Belleville spring washers with the crown up toward the nut or bolt head, with the concave side of the Belleville bearing on a heavy-duty, wide series flat washer of larger diameter than the Belleville. Tighten nuts sufficient to flatten Belleville and leave in that position. Lubricate hardware with joint compound prior to making connection. Wire brush and apply joint compound to conductor prior to inserting in lug.
- c. Terminate aluminum conductors to aluminum bus by using all-aluminum nuts, bolts, washers, and lugs. Wire brush and apply joint compound to conductor prior to inserting in lug. Lubricate hardware with joint compound prior to making connection; if bus contact surface is unplated, scratch-brush and coat with joint compound (without grit).

3.1.17 Medium Voltage Cable Terminations

Provide terminating devices and materials to protect medium voltage cable terminations from accidental contact, deterioration of coverings, and moisture. Make terminations by using materials and methods specified herein and as designated by the written instruction of the cable manufacturer and termination kit manufacturer. Termination for high-voltage cables shall be rated, and be capable of withstanding test voltages, in accordance with IEEE 48. Terminations of single- and multiconductor cables shall include the securing and sealing of the sheath and insulation of the cable conductors, stress relief and grounding of cable shields of shielded cable, and grounding of neutral conductors, metallic sheaths, and armor. Adequately support cables and cable terminations to avoid any excessive strain on the termination and the conductor connection.

3.1.18 Medium Voltage Cable Joints

Provide power cable joints (splices) suitable for continuous immersion in water [and direct burial]. Make joints only in accessible locations in manholes or handholes by using materials and methods specified herein and as designated by the written instructions of the cable manufacturer and the joint kit manufacturer. [Clearly mark joints buried directly in earth by an identification slab.] Size connectors properly for the cable being connected and crimp using a full circle compression tool.

3.1.18.1 Joints in Shielded Cables

NOTE: For LANTNAVFACENGCOM: The bracketed sentence applies to Naval Base, Norfolk, VA, 34.5 kV distribution systems.

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. [Insulate cable shield for 34.5 kV system splices into sections at each splice to prevent circulating currents in the shield. Ground each

insulated section at one point only. The length of cable shield for single point grounding shall not exceed 457 meters 1,500 feet when three cables occupy the same duct. Ground ends of insulated sections at the cable terminal only.] Provide a bare copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods shall be as specified elsewhere in this section. Wire shall be trained to the sides of the enclosure to prevent interference with the working area.

[3.1.18.2 Lead-Sheathed Cable Joints

Prepare for jointing by cutting the lead sheath back the required distance and belling the remaining cable sheath to prevent damage to the conductor insulation. Clean insulated conductors and tape and cut insulation to expose bare wires for the required distance. Clean conductor thoroughly, then join by a split or slotted tinned copper connector or other approved connector. Solder conductors and connector and wrap joint with compatible semiconducting tape and insulating tape as recommended by the manufacturer so that insulation will be at least equal to the rated insulation of the cable.[For cable over 7500 volts operating voltage, provide cable shield splice.] Center the lead sleeve over the prepared joint, [boil out the area with hot insulating oil,] [fill with an insulating oil] [fill with an insulating compound] and solder seal.[Alternately use a factory-engineered heat shrinkable joint kit to complete the splice. Heat shrinkable joint kit shall contain necessary materials except connector to provide oil stop and oil seal, electrical stress control, insulation, shielding and environmental sealing. Kit shall allow for external grounding.]

]3.1.19 Cable End Caps

Cable ends shall be sealed at all times with coated heat shrinkable or cold-shrink end caps. Cables ends shall be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps shall remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable or cold-shrink end caps. Cable which is not sealed in the specified manner at all times will be rejected.

[3.1.20 Live End Caps

Provide live end caps for single conductor medium voltage cables where indicated.

]3.1.21 Fireproofing of Cables in Manholes, Handholes and Vaults

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in manholes, handholes, and vaults.

3.1.21.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

[3.1.21.2 Tape-Wrap

Tape-wrap lead-sheathed, other metallic-sheathed, or metallic armored cables without a nonmetallic protective covering over the sheath or armor

prior to application of fireproofing. Wrap shall be in the form of two tightly applied half-lapped layers of a pressure-sensitive 0.254 mm 10 mil thick plastic tape, and shall extend not less than 25 mm one inch into the duct. Even out irregularities of the cable, such as at splices, with insulation putty before applying tape.

3.1.22 Grounding Systems

NOTE: The Designer must determine the grounding requirements for each project. Show all necessary ground rods and ground girdles on the drawings.

Noncurrent-carrying metallic parts associated with electrical equipment shall have a maximum resistance to solid earth ground not exceeding the following values:

[Generating and control equipment 1000 volts and over	1 ohm]
[[Main substations] [, distribution substations] [, switching stations] [, primary distribution stations enclosed by fences]	
[500 kVA or less	5 ohms]
[500 kVA to 1000 kVA	5 ohms]
[1000 kVA or over	3 ohms]]
[Pad-mounted transformers without protective fences	5 ohms]
[Ground in manholes, handholes, and vaults	5 ohms]
[Grounding other metal enclosures of primary voltage electrical and electrically-operated equipment	5 ohms]
[Grounded secondary distribution system neutral and noncurrent- carrying metal parts associated with distribution systems and grounds not otherwise covered	5 ohms]

When work in addition to that indicated or specified is directed in order to obtain the specified ground resistance, the provisions of the contract covering "Changes" shall apply.

3.1.22.1 Grounding Electrodes

Provide cone pointed ground rods driven full depth plus 150 mm 6 inches, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.

3.1.22.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, [excepting specifically those connections for which access for periodic testing is required,] by exothermic weld or compression connector.

- a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.
- b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.22.3 Grounding Conductors

Unless otherwise indicated, grounding conductors shall be stranded-bare copper conforming to ASTM B8, Class B, for sizes No. 6 AWG and larger, and shall be solid-bare copper conforming to ASTM B1 for sizes No. 8 and smaller. Cable sheaths, cable shields, conduit, and equipment shall be grounded with a minimum of No. 6 AWG.

3.1.22.4 Ground Cable Crossing Expansion Joints

Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

[3.1.22.5 Ground Rod Connections

**NOTE: Do not use this paragraph except when
insulated ground is required; for others, use
grounding connection paragraph.**

Connect ground rods only to insulated copper ground conductor and weld the connection. Insulate entire area of the rod in the vicinity of the weld and the connecting wire and seal against moisture penetration.

]3.1.22.6 Fence Grounding

[Fences shall be grounded as indicated.] [Fences shall be grounded with a ground rod at each fixed gate post and at each corner post. Drive ground rods until the top is 305 mm 12 inches below grade. Attach a No. 4 AWG copper conductor, by exothermic weld to the ground rods and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 305 mm 12 inches of fence mesh and fasten by two approved bronze compression fittings, one to bond wire to post and the other to bond wire to fence. Each gate section shall be bonded to its gatepost by a 3 mm by 25 mm 1/8 inch by 1 inch flexible braided copper strap and ground post clamps. Clamps shall be of the anti-electrolysis type.]

]3.1.22.7 Manhole Grounding

**NOTE: Use bracketed sentence when 4-wire circuit
including grounded neutral is provided.**

Loop a 4/0 AWG grounding conductor around the interior perimeter, approximately 305 mm 12 inches above finished floor. Secure the conductor to the manhole walls at intervals not exceeding 914 mm 36 inches. Connect the conductor to the manhole grounding electrode with 4/0 AWG conductor. Connect all incoming 4/0 grounding conductors to the ground loop adjacent to the point of entry into the manhole. Bond the ground loop to all cable shields, metal cable racks, and other metal equipment with a minimum 6 AWG conductor.[Provide direct connections to the grounding conductor with 600 volt insulated, full size conductor for each grounded neutral of each feeder circuit which is spliced within the manhole.]

[3.1.23 Special Conditions

During the construction of duct banks and underground structures located in streets, the streets shall remain open to traffic. Plan and execute the work to meet this condition.[At locations where duct banks cross railroad tracks and the work requires closing of the tracks, secure permission from the Contracting Officer for each track closure.]

]3.1.24 Excavating, Backfilling, and Compacting

Provide under this section as specified in Section 02315N, "Excavation and Fill".

3.1.25 Reconditioning of Surfaces

3.1.25.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct [or direct burial cable]. Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged with sod of equal quality to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding.

3.1.25.2 Paving Repairs

**NOTE: Where paving repairs are a very minor part of
project, the first bracketed option may be used;
otherwise, use the second bracketed option and
include other sections as needed (also include
necessary cutting and patching details on the
drawings.)**

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists, [restore such surface treatment or pavement to the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.] [make repairs in accordance with Section 02951N "Pavement Removal and

Replacement."]

3.2 FIELD QUALITY CONTROL

3.2.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.2.1.1 600 Volt Cable Tests

Perform tests after wiring is completed, connected, and ready for operation, but prior to placing systems in service and before any branch circuit breakers are closed.

a. Visual and Mechanical Inspection

1. Inspect cables for physical damage and proper connection in accordance with contract plans and specifications.
2. Check cable color coding for compliance with contract specifications.

b. Electrical Tests

1. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts DC for 1 minute. Minimum insulation - resistance values shall not be less than 50 megohms.
2. Perform continuity test to insure proper cable connection.

3.2.1.2 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

1. Inspect exposed cable sections for physical damage.
2. Verify that cable supplied is in accordance with contract plans and specifications.
3. Inspect for proper shield grounding, cable support, and cable termination.
4. Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius.
5. Inspect for proper fireproofing.
- [6. If cables are terminated through window-type CT's, make an inspection to verify that neutrals and grounds are properly terminated for proper operation of protective devices.]
7. Visually inspect jacket and insulation condition.

8. Inspect for proper phase identification and arrangement.

b. Electrical Tests

1. Perform a shield continuity test on each power cable by ohmmeter method.[For 34.5 kV split shield systems, provide temporary electrical connection between cable shields at each splice prior to conducting test.] Record ohmic value, resistance values in excess of 10 ohms per 305 meters 1000 feet of cable must be investigated and justified.

NOTE: Use the following DC test voltages:

	<u>EPR & XLP</u>	<u>PILC**</u>
5,000 Volt Cable	25 kV	30 kV
15,000 Volt Cable, 100% Insulation	*53 kV/55 kV	65 kV
15,000 Volt Cable, 133% Insulation	*53 kV/65 kV	85 kV
25,000 Volt Cable, 100% Insulation	*78 kV/80 kV	105 kV
25,000 Volt Cable, 133% Insulation	*78 kV/100 kV	135 kV
28,000 Volt Cable, 100% Insulation	*78 kV/85 kV	115 kV
35,000 Volt Cable, 100% Insulation	100 kV	145 kV
35,000 Volt Cable, 133% Insulation	*103 kV/124 kV	

*Use lower value when insulated connectors are connected to the cable being tested.

**When PILC cable has nonmetallic outer jacket, reduce these values by 10 percent.

The table in the paragraph below should be edited for the cables and the test values included in the project.

2. Perform a DC high-potential test on all cables. Adhere to precautions and limits as specified in the applicable NEMA/ICEA Standard for the specific cable. Test procedure shall be as follows, and the results for each cable test shall be recorded as specified herein. Field acceptance test voltage shall be as follows:

<u>CABLE RATING</u>	<u>DC TEST VOLTAGE</u>
5 kV	25 kV
15 kV	55 kV for cables without insulated connectors
15 kV	65 kV for cables without insulated connectors
15 kV	53 kV for cables with insulated connectors
25 kV	80 kV for cables without insulated connectors
25 kV	100 kV for cables without insulated connectors
25 kV	78 kV for cables with insulated connectors
35 kV	100 kV

- (a) Current-sensing circuits in test equipment shall measure only the leakage current associated with the cable under test and shall not include internal leakage of the test equipment.
- (b) Record wet- and dry-bulb temperatures or relative humidity and temperature.

- (c) Test each section of cable individually.
- (d) Individually test each conductor with all other conductors grounded; Ground all shields.
- (e) Terminations shall be properly corona-suppressed by guard ring, field reduction sphere, or other suitable methods as necessary.
- (f) Ensure that the maximum test voltage does not exceed the limits for terminators specified in IEEE Standard 48 or manufacturer's specifications.
- (g) Apply the DC high-potential test in at least five equal increments until maximum test voltage is reached. No increment shall exceed the voltage rating of the cable. Record DC leakage current at each step after a constant stabilization time consistent with system charging current.
- (h) Raise the conductor to the specified maximum test voltage and hold for fifteen (15) minutes. Record readings of leakage current at 30 seconds and one minute and at one-minute intervals thereafter. Provide a graphic plot of readings with leakage current (Y axis) versus voltage (X axis) at each increment.
- (i) Reduce the conductor test potential to zero and measure residual voltage at discrete intervals.
- (j) Apply grounds for a time period adequate to drain all insulation stored charge.

3.2.1.3 Grounding System

a. Visual and mechanical inspection

- 1. Inspect ground system for compliance with contract plans and specifications

b. Electrical tests

- 1. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

3.2.2 Follow-Up Verification

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer

shall be given 5 working days advance notice of the dates and times of checking and testing.

3.3 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurement commonly agreed to by the manufacturers or other parties. The inch-pound and metric measurements are as follows:

<u>PRODUCTS</u>	<u>INCH-POUND</u>	<u>METRIC</u>
a. Fireproofing Tape		
- Thickness	30 mils	0.762 mm
- Width	3 inches	75 mm
b. Pull Wire		
- Tensile strength	200 pounds	890 Newton
c. Ground Rod		
- Diameter	3/4 inch	19 mm
- Length	10 feet	3050 mm
d. Concrete		
- Strength	3000 psi	20 MPa
- Strength	3500 psi	25 MPa
- Strength	4000 psi	30 MPa
e. Conduit		
- Diameter	1/2 inch	16 mm
	3/4 inch	21 mm
	1 inch	27 mm
	1-1/4 inch	35 mm
	1-1/2 inch	41 mm
	2 inch	53 mm
	2-1/2 inch	63 mm
	3 inch	78 mm
	3-1/2 inch	91 mm
	4 inch	103 mm
	5 inch	129 mm
	6 inch	155 mm

LIST OF SKETCHES

Sketches are available in metric (SI) and U.S. Customary (IP) system dimensions. Sketch titles and style numbers are unchanged for both types.

The metric values indicated are a conversion of the IP system dimensions.

Do not include list of sketches, or sketches themselves, in project specifications. Use manhole / handhole sketches as details on drawings whenever possible. If special features are required for a project, do not modify sketches, but indicate these changes on notes below the sketch. The "UG" style numbers and dates should remain on the drawing details.

<u>SKETCH NUMBER</u>	<u>TITLE</u>
UG - 1	Standard Electrical Manhole (Nontraffic), Types 1 and 2
UG - 2	Standard Electrical Manhole (Traffic), Types 3 and 4
UG - 3	Standard Electrical Manhole (Airfield), Types 5 and 6
UG - 4	Standard Electrical Handhole (Nontraffic), Types 1 and 2
UG - 5	Standard Electrical Handhole (Traffic/Airfield), Types 3 and 4
UG - 6	Standard Electrical Handhole (Nontraffic), (Composite/Fiberglass) Types 5, 6, 7, 8 and 9
UG - 7	Details (Pulling-In Irons, Cable Rack, and Duct Entrance)

NOTE: The Sketches can be found at
http://www.efdlant.navfac.navy.mil/lantops_04/home.htm.
in ACAD format under CAD Details/Electrical and in
pdf format under LINKS/NAVFAC Criteria Home
Page/Publications/Guide Specifications/Graphics.

NOTE: Suggestions for improvement of this
specification will be welcomed using the "Agency
Response Form" located in SPECSINTACT under "System
Directory" or DD Form 1426. Suggestions should be
forwarded to:

Atlantic Division
Naval Facilities Engineering Command
Attention EICO
1510 Gilbert Street
Norfolk, VA 23511-2699

FAX: (757) 322-4416 or DSN 262-4416

-- End of Section --